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TESTING OF NEW MODELS OF GAS-GENERATOR TRUCKS FOR USE WITH WOOD FUEL

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/Figures referred to are appended./

During 1949 - 1950 joint tests were conducted on experimental models of gas-generator trucks operated on wood fuel.

The purpose of the tests was to reveal the technical and economic characteristics of new designs of gas-generating units, and their operational reliability in comparison with the ZIS-21A gas-generating unit. The trucks tested were those of the All-Union Scientific Research Automobile and Automobile Motor Institute (NAMI); the Ural Automobile Plant imeni Stalin (UralZIS); the Central Scientific Research Institute of Mechanization and Power Engineering in Logging (TsNIIME); the Leningrad Forestry Engineering Academy imeni S.M. Kirov (LTA); and the Automobile Administration under the Council of Ministers Latvian SSR (designed by Engineer Kron).

Of the 19 trucks tested, six were NAMI-G78, six were UralZIS-4G and two were standard UralZIS-21A trucks, all of which operated on standard logs (drevesnaya churka). Gas generators designed by Kron operated on logs of higher moisture content (up to 60 percent absolute). One truck with an LTA fitting on a ZIS-21A gas generator operated on any logs regardless of moisture content.

In addition, two trucks worked with TsNIIME-20 gas generators operating on green firewood one half meter in length.

NAMI and UralZIS gas-generating units differed from the ZIS-21A units in the type of gas generators used and in their method of filtering and cooling gas.

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The gas generators of the NAMI and UralZIS units employ a return gasification process, with complete heating of the hopper. They have chambers with five tuyeres, and fire grates with a vibrating central section.

NAMI gas generators were provided with chambers of two types: welded ones with replaceable inserts of chromium cast iron (Figure 1a) or dismountable ones with replaceable conic inserts and steel necks (Figure 1b).

The UralZIS gas generators had welded cylindrical chambers with steel conical inserts fused into them (Figure 1c).

Coarse filtration and cooling of gas in NAMI-G78 and UralZIS-4G trucks were accomplished in separate assemblies in contrast to the ZIS-21 trucks, in which coarse filtration and cooling of gas take place in a single unit.

The gas-generating units of the TsNIIME and Kron designs differed from the ZIS-21A units only in the arrangement of the generator itself. The system of filtering and cooling gas in these units is similar to that of the ZIS-21A system.

The Kron gas generator employs the return process [of gasification] with complete heating of the hopper. It has a welded conical gasification chamber with two-tuyere flanges and two welded conical inserts of heat-resistant steel (Figure 1d).

The TsNIIME-20 gas generator, rectangular in form, employs the return gasification process without heating of the hopper. A rectangular gasification chamber, welded of sheet steel, has 16 tuyeres. Metal strips on which square cast-iron inserts with round necks rest freely are welded to a lower cylindrical gasification chamber (Figure 1e).

Air is fed into the gasification zone by a special motor-driven blast fan. At the same time moisture vapors and products of the dry distillation of fuel are forced out into the atmosphere through an outlet in the lid of the hopper.

The LTA gas-generating unit is the ordinary ZIS-21A with an adaptation for the gasification of green logs. The adaptation consists of a special blower for forcing the air into the gas generator, and a device for drawing into the generator the exhaust gases of the motor, which gases dry the logs present in the hopper. Moisture vapors, products of the dry distillation of fuel, and the exhaust gases of the motor are discharged from the gas generator into the atmosphere through an aperture in the lid of the hopper. A cast-steel ZIS-21A gasification chamber is shown in Figure 1f.

Conditions of the Test

The joint tests of gas-generator trucks were conducted by transporting firewood and industrial lumber, with loading conforming to the specifications of the Ministry of Timber and Paper Industry. The tests lasted from 16 August to 1 February 1950.

The trucks were stationed at a logging station truck base without garage facilities.

The average hauling distance was 22-25 kilometers. The roads were through forest and country, with sharp turns, deep ruts and hollows, and unmarked grades for the most part. The ground was sandy. Birch logs were used as fuel. The NAMI and UralZIS trucks operated on logs (naturally dryed) with a 24-percent absolute moisture content. The LTA trucks used logs averaging 80

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percent absolute moisture content, while the Kron trucks used logs with a 50-percent absolute moisture content. For the TsNIIME trucks birch firewood with an 80-percent moisture content was used.

During a run of 1,000 kilometers, the trucks operated on pine logs and firewood. The average moisture content of the pine logs was 23 percent; that of the pine firewood was 75 percent.

Second-grade gasoline was used as auxiliary fuel. For lubrication of the motors, automobile lubricating oil 10 was used.

Test Results

Out of the 19 trucks, 16, in compliance with the testing program, traveled a distance of 8,000 kilometers (after being run 1,000 kilometers), carrying a load for 4,000 kilometers. Each motor operated for an average of 500 hours.

The average fuel consumption of NAMI-G78, UralZIS-4G, and ZIS-21A trucks operating on a 100-kilometer run without hauling trailers was 134 kilograms of birch logs. Average fuel consumption when trailers were hauled was 194 kilograms of pine logs.

The average fuel consumption of TsNIIME-20 trucks operating without trailers (using green birch firewood 500 millimeters long), and of LTA trucks (using green birch logs), was 273 kilograms for a 100-kilometer run. In terms of absolutely dry wood this figure would be 40 percent higher than for trucks operating on dry fuel.

A truck with a Kron gas generator, operating on birch logs with higher moisture content (51 percent), averaged a fuel consumption of 142 kilograms on a 100-kilometer run.

On the highway the dynamic qualities of the trucks approximated one another rather closely. The maximum velocity from a running start on a one-kilometer horizontal strip reached 53-59 kilometers per hour, except for a truck with a Kron gas generator, which attained a speed of 41.8 kilometers per hour. Speed attained from a standstill on this strip was 35-40 kilometers per hour. The speed attained on a grade (400 meters long, at an incline of 4.5 degrees) was 15-18 kilometers per hour.

Starting Qualities

In winter, before starting a motor, hot water was poured into its cooling system, crankcase grease was preheated in a pan, and the intake manifold was preheated with a torch.

The time spent in kindling the gas generator and starting the motors on gas took 5.5-9 minutes, except that for trucks with Kron gas generators, which took 13 minutes.

The consumption of gasoline for a single starting of a motor in winter (after night parking) for NAMI, ZIS-21A trucks, and for Kron gas generators amounted to an average of 1.12 liters. [Ts]NIIME and LTA trucks consumed 2.0-2.1 liters of gasoline. The higher consumption of gasoline by these trucks was caused by the work of the truck engine (during the kindling period) which operates the blast fan of the gas generator.

UralZIS-4G trucks used the least amount of gasoline (0.75 liter) in starting.

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All motors started on gas after a short parking period except those of TsNIIME-20 trucks. Of these, 45 percent of the hot motor starts took place on gasoline (owing to an inability to start on gas), with subsequent conversion to gas.

For all trucks tested, hot motor starting time was 3 minutes, with all the starters engaged the same number of times.

Wear on Motor Parts

New ZIS-21A motors off the assembly line were installed on all the trucks being tested.

Micrometer data reveals that deterioration of the motor components of NAMI-G78 trucks and of trucks with a ZIS-21A filter system (ZIS-21A, LTA, TsNIIME-20, and Kron) was practically identical.

The average maximum cylinder wear in the motors of six trucks with the ZIS-21A filter system was 0.107 millimeter after a run of 10,000 kilometers; in six NAMI-G78 trucks it was 0.109 millimeter. Wear on the cylinders of UralZIS-4G trucks was 0.203 millimeter, almost twice as high as in the first two groups of motors.

The wear on piston rings and piston ring grooves in the different groups showed approximately the same ratio.

This data shows that the quality of the gas filter in NAMI trucks, and trucks with the ZIS-21A filtration system, is identical. The quality of the filtration system of UralZIS-4G trucks is considerably below that of the first two groups.

The average oil consumption of the motors was 0.8-1.87 liters for a run of 100 kilometers.

The coke content of the oil used was 1.4-2.6 percent; ash content, 0.12-0.58 percent; and mechanical impurities, 0.27-0.83 percent.

Vacuum and Gas Temperature

The vacuum and the gas temperature of the gas-generating units were measured while the trucks were driven along the highway in direct drive, with a load of 2.5 tons at constant speed. The vacuum in front of the mixer in all tested trucks, except those with Kron gas generators (where it was equal to a 100-195 millimeter column of mercury) was practically the same, and was equal to a 30-50 millimeter column of mercury.

The temperature in front of the mixer fluctuated within the limits of 18-30 degrees centigrade. It was measured during operation on birch logs, with the surrounding air at a temperature of from plus 2 to minus 4 degrees centigrade.

Maintenance of Gas-Generating Units

The time spent in cleaning the elements of the gas-generating unit for a run of 1,000 kilometers ranges between one and 1.5 hours for NAMI, UralZIS-4G, TsNIIME-20, and ZIS-21A trucks. It takes 2-3 hours for LTA trucks with a Kron gas generator.

Since the NAMI and UralZIS-4G gas generators have fire-grate grids, the time spent in cleaning the cinder box is no more than 3-4 minutes.

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The cleaning of coarse gas filters (cyclone dust extractors) in both NAMI and UralZIS-4G trucks is considerably easier than cleaning the coarse filters of ZIS-21A trucks. Cleaning the latter coarse filter takes 20 minutes; cleaning the NAMI and UralZIS dust extractors takes only 3 minutes.

During winter testing of the trucks, after a night's parking without garage shelter, and at times when in motion, there have been cases in which the fine gas filters have frozen. The greatest number of these cases occurred on trucks with NAMI units. Only in the case of one NAMI truck and the TsNIIME-20 trucks was no freezing of the fine gas filters observed while in motion.

Breakdowns and Defects of Gas-Generating Units During Testing

The greatest number of breakdowns and defects during the tests occurred on TsNIIME-20 trucks. The most serious of these were cracks in the tuyere flange of the combustion chamber (in both gas generators). Deterioration of the gaskets between the upper and lower parts of the gas generator as well as the burning through of hose connections, was observed. In addition, the blast fans repeatedly went out of order. This defect was also characteristic of the LTA trucks.

In Kron gas generators, the gasification zone was often burned out. In one of the gas generators, cracks appeared in the region where a heat-resistant insert was welded to the gasification chamber. In UralZIS-4G trucks, there were four cases of breakage in the gas inlet from the fine filter to the mixer.

There were no breakdowns in NAMI-G78 trucks, but in one out of six trucks there was a crack in the welded seam of the pipe connecting the dust extractor with the cooler.

Condition of the Gas-Generating Units After Testing

The gasification chambers of the gas generators of all groups except NAMI trucks (these were welded, with cast inserts of chromium cast iron, or welded removable ones) and one chamber of a TsNIIME-20 gas generator, which was repaired during the course of the tests, had different defects after the tests. A deformation of the movable part of the grate and a burned place in the stationary part were revealed in the fire grates of the UralZIS-4G gas generators.

In TsNIIME-20 gas generators, a deformation of the horizontal partitions of the housing was disclosed. Two housings of the UralZIS-4G gas generators showed fractures in the places where the supporting pipe elbows were welded. The gas-generator housings of other trucks had no defects.

The coarse filters and dust extractors of all units were without defects except for the UralZIS-4G dust extractor, where the bracing of the baffle plate was insecure.

Evaluation of Designs

From the point of view of arrangement of the elements of the gas-generating unit on a truck, the most successful are the NAMI-G78A and ZIS-21A models, which have a compact arrangement and the shortest length of piping.

The arrangements of the elements of the NAMI-G78V and the UralZIS-4G gas-generating units are less successful. The location of the cooler in front of the radiator made longer pipelines necessary.

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The distribution of the elements in the gas-generating units of the Kron, TsNIIME-20, and LTA models is identical with that in the ZIS-21 units.

The fire grates in the NAMI-G78, UralZIS-4G, and TsNIIME-20 gas generators simplify and facilitate cleaning of the ash pit and servicing of the trucks. The threaded hatches of the gas generators, by excluding the seepage of air, extend the time before servicing of the gasification chamber is required.

Raising the hopper seam above the gas-generator housing in NAMI-G78 and UralZIS-4G units protects the motor from gumming up in event of breakage of the seam of the hopper flange.

The most successful designs of welded chambers in the trucks were the NAMI-G78A and NAMI-G78B, which had cast inserts of chromium cast iron. These two chambers proved practically identical in quality in the tests.

A welded chamber is more easily repaired than a ZIS-21A chamber, and repeated repairs are practicable.

The gasification chamber of a Kron gas generator is very complicated and heavy, and cannot be repaired. It weighs 50 kilograms more than the chamber of a ZIS-21A gas generator, and, as the tests revealed, is short-lived.

The TsNIIME-20 gas generators have the following defects: complex design (the coupling of cylindrical and rectangular parts, poorly designed connections of the upper and lower sections of the gas generators, deterioration of gaskets, and cracks in the lugs of bracing bolts); deformation of the walls of the gas generator; poor gas take-off, causing a great amount of dust in the filter and burned places in the hoses; less efficient drive for the fitting for cleaning the fire grate; considerable weight (80 kilograms greater than in a ZIS-21A truck); and the necessity of stoking the hopper every 18-20 kilometers and of carefully stacking wood in the generator, which is inconvenient for the crew from the standpoint of health.

The coarse filters in the ZIS-21A unit, fulfilling the function of a gas cooler, are replaced by a dust extractor and a gas cooler in NAMI-G78 and UralZIS-4G units.

In the quality of their work, dust extractors are practically equivalent to ZIS-21A coarse filters.

The NAMI dust extractors, as compared with the ZIS dust extractors, provide better gas filtration.

Weight Data on the Gas-Generating Units

	Total Wt (kg)	Wt of Metal (kg)	
ZIS-21A	518	518	Standard
NAMI-G78A	375	355	32% saved
NAMI-G78B	361	349	33% "
NAMI-G78V	380	380	27% "
UralZIS-4G	402	402	23% "

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	Total Wt (kg)	Wt of Metal (kg)		
Kron	567	567	10%	overconsumed
TsNIIME-20	626	626	21%	"
LTA	551	551	6%	"

Taking account of the results of the joint tests, the Ural Automobile Plant, together with NAMI, worked out a design for a new gas-generating unit (UralZIS-352), experimental models of which were made up for control tests. During the fabrication of the UralZIS-352 gas-generating unit, the NAMI-G78A unit was accepted as a basis. This unit, in comparison with the ZIS-21A unit, is distinguished by the following advantages:

1. Less weight.

2. Ability to operate on green logs.

3. A special adjustment for starting under winter conditions.

4. Durability and simplicity of repairing the gasification chamber.

5. A vibrating fire grate in the gas generator, which prevents overloading of the gasification chamber with charcoal. As a result, the consumption of charcoal is sharply reduced in operation, and the handling of the generator is simplified.

6. A dust extractor, without perforated plates for coarse filtration of gas, which simplifies handling in operation.

7. Air-tight threaded hatches on the gas generator, greater road clearances, and a series of other features which promote dependability and simplicity of operation.

8. More reliable electrical equipment.

Below is a description of the NAMI-G78A gas-generating unit, which exhibited the best results in the tests, in comparison with the other units.

The NAMI-G78A gas-generating unit (Figure 2), consists of a gas generator, a dust extractor (coarse gas filter), a gas cooler, a fine gas filter, and a kindling fan.

The gas generator itself (Figure 3) consists of a housing welded out of 2-millimeter sheet steel, a hopper, to which are welded a loading hatch with a lid, and a gasification chamber.

The housing has two threaded hatches, the lower one for cleaning the cinder pit, the upper for stacking charcoal around the chamber and for cleaning that area (in case of necessity).

The welded fire grate consists of a stationary circular section and a vibrating central one.

The hopper is welded out of steel 2 millimeters thick. The cylindrical gasification chamber is nonremovable and welded out of 8-millimeter-thick sheet steel. Air is delivered through a distributing box with a reverse valve, along four different pipes, to five tuyeres 13 millimeters in diameter.

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A removable insert (with an opening 140 millimeters in diameter) is securely fastened by four pins, whose caps are welded to the exterior surface of the gasification chamber. The insert of the chamber is cast out of chromium cast iron. The generator is kindled through the reverse valve of the distributing box.

The cyclone dust extractor (Figure 4) consists of a steel welded housing (diameter, 162 millimeters). Inside the upper section of the housing is a working chamber in the form of a spiral, set at an angle of 15 degrees. The spiral is located around the exhaust pipe. The tangential intake pipe is also inclined at an angle of 15 degrees and is welded directly to the spiral of the working chamber. To the working chamber of the dust extractor a cone is welded through which falling particles of dust drop into the dust collector. The dust collector has hatches for cleaning purposes.

The welded gas cooler, located on the roof of the truck's cab, consists of 11 consecutively connected pipes 63.5 millimeters in diameter. Hatches with lids serve for cleaning the dust in the pipes.

The fine gas filter consists of a steel welded housing, with intake and exhaust pipes welded to it. A distributing box and two grates are located within the housing. Gas passes through openings in the lower part where it comes in contact with the surface of the water, and, in this way, is partially freed from dust. Then the gas passes through two layers of woody filtering material /drevesnaya setka; apparently conifer needles. See Figure 2, caption 6./ which rest on metal rings, and goes out through the outlets.

The filter has four hatches for loading and washing the metal rings and woody filtering material. There is a special opening to limit the level of the condensed water.

There is a kindling fan with an electric motor of 135 watts and 12 volts.

/Figures follow./

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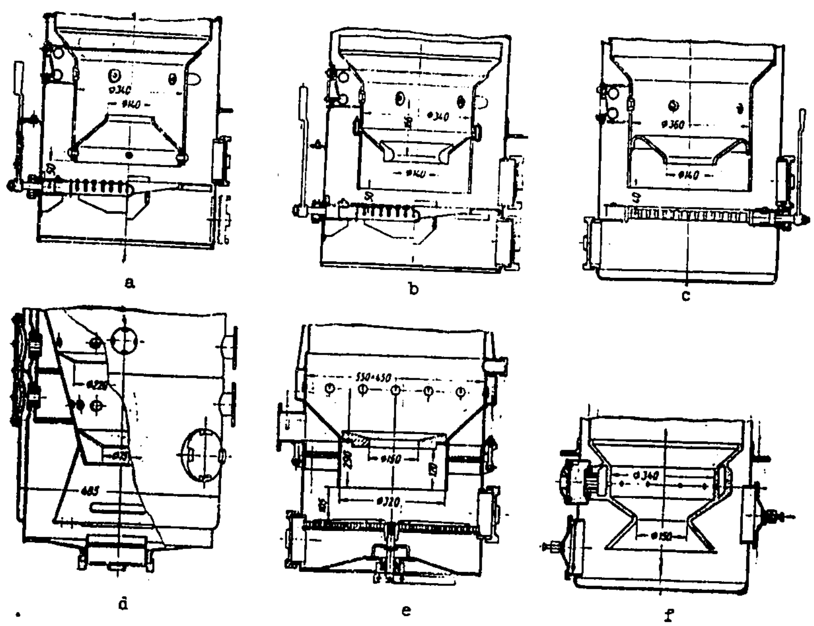

Figure 1. Diagrams of Gasification Chambers of the Following Generators: a,b - NAMI-G78; c - UralZIS-4G; d - Kron; e - TsNIIME-20; f - LTA

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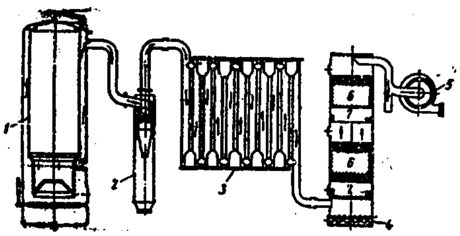

Figure 2. Diagram of the NAMI-G78A Gas-Generating Unit: 1 - gas generator; 2 - dust extractor; 3 - cooler; 4 - fine filter; 5 - kindling fan; 6 - conifer needles (khvoynye igly); 7 - metal rings

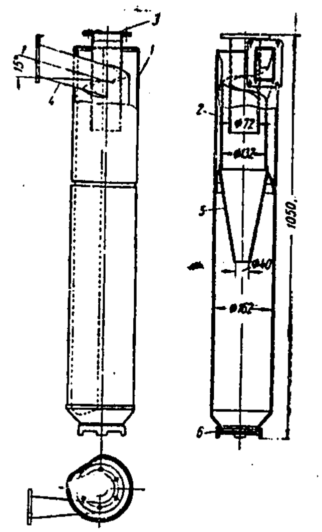

Figure 4. Dust Extractor of the NAMI-G78A,B,V Gas-Generating Unit: 1 - housing; 2 - working chamber; 3 - gas outlet pipe; 4 - gas inlet pipe; 5 - cone for directing particles of dust into the dust collector; 6 - threaded hatch

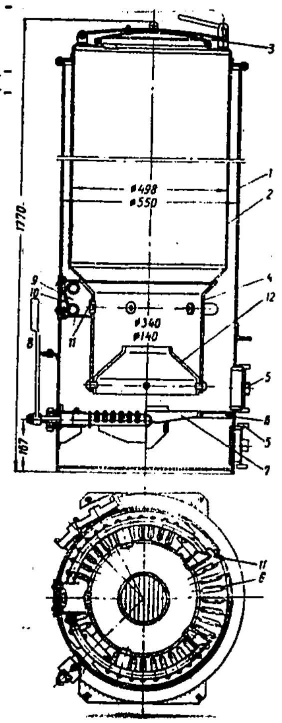

Figure 3. NAMI-G78A Gas Generator: 1 - housing; 2 - hopper; 3 - lid; 4 - gasification chamber; 5 - threaded hatches; 6 - stationary grate; 7 - vibrating grate; 8 - grate activating handle; 9 - air distributing box; 10 - reverse valve; 11 - tuyeres; 12 - removable insert of the gasification chamber

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